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TIL: AN INNOVATIVE TOOL FOR THE RECRUITMENT OF BACHELOR ENGINEERING STUDENTS IN ITALY

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ABSTRACT

This paper summarizes the guidelines and the main results of the set-up of an access Test in Laib –TIL performed at Politecnico di Torino, Italy, during the last decade. Many reasons forced to define this proprietary tool, such as the introduction of the numerus clausus and the consequent need of an effective and robust evaluation process associated to merit, the improvement of the attractiveness at the national and international level, and the reduction of the drop-out rate. This test was able to supply several functions, useful both for the university and the potential students. It demonstrated to be a reliable and predictable tool for evaluating the competence background needed for a successful career in a technical university. In addition, it is a self-assessment test for the applicants able to contribute to a conscious individual choice.

KEYWORDS: admission test; career prediction; drop-out; engineering bachelor; recruitment.

INTRODUCTION:

Literature context:

In literature students selection has been proposed as a useful tool to rank from a pool of applicants, especially when demand exceeds supply (Harman 1994), but also to improve the quality of the student population, consequently reducing the drop-out rate, as well as the duration of the career (Schaefler 1962); (Selim e Al-Zarooni 2009); (Pascoe 1999); (Urpo 1990).

The need for developing selection mechanisms able to assure equity and fairness in higher education was already stressed (Pitman 2016); (Geschwind 2017). A selection process must be transparent, simple and equitable and it can be associated with merit, i.e. with talent, skill, intelligence, ability, and effort (Liu 2011), one of the main interests of the university being to acquire the most talented students.

The introduction of an entrance examination is based on the belief that earlier school success does not necessarily lead to success in higher education (Ahola e Kokko 2001); (Selim e Al-Zarooni 2009); (Graeffe 1989). Therefore today, of particular importance, is the predictability of the test, even if in some cases literature supports a better predictor function for medicine (Strupler Leiser e Wolter 2015); (Migliaretti, et al. 2017); (Alia e Ali 2010), nurse (Gale, et al. 2016) and STEM (Schultz and Austin 1987) than for business administration (Ahola e Kokko 2001), and social work students (Lyrén 2008).

If the student's point of view is considered, the test should be designed to promote a self-assessment exercise, to be flexible and available many times to give the student the opportunity to fill the potential gaps (Eitel, Benito e Scheiter 2017); (Dunlosky e Rawson 2015) and to limit failures induced by emotional situations (Daniels e Gierl 2017). In addition, it can aid in limiting the gender gap. In fact, although female perform as well as male students in engineering, women's self-perception of their own performance and the confidence in their skills are often lower than that of male students (Godwin, et al. 2015).

It has been highlighted that the high school grades alone cannot give correct indication about the career choice (Qian, Chi e Bai 2014) and they cannot predict the generalist standardized test results (Godwin, et al. 2015) when engineering courses are concerned due to the specific characteristics. In fact, in middle and high school students, usually, do not have direct engineering experience, while they achieve a better perception of other scientific fields, like mathematics, physics or chemistry (Marra, et al. 2009); (Seymour e Hewitt 1997); (Williams, Engerman e Fleming 2006).

University background and objectives:

In the international frame above summarized, Politecnico di Torino (from now on referred to as PoliTo, see www.polito.it) developed its own selection strategies. To better understand the decision taken and the tool adopted, some information concerning the institution as well as its context are given in the following.

PoliTo, founded in 1859 on the basis of the French Ecole Polytechnique model, is an Italian Technical University and it provides training in the macro-areas of Engineering and Architecture.

PoliTo applies the Bologna model, that is the first level of training (Bachelor, BS, identified in Italian as Laurea) lasting three years, and a second level (Master of Science, MS, Laurea Magistrale) lasting two years, with a possible follow-up in a three years' doctoral path.

It offers 50 educational programs, 40% of which are BSs, split into the various disciplines of Engineering (industrial, ICT, civil-environmental, management) and Architecture (more details can be found at (Politecnico di Torino s.d.)). The Italian university system is based on credit-accumulation (180 credits for BS and 120 credits for MS) and each exam is passed if the score ranges between 18 and 30. At PoliTo to gain access to the second year, students must overcome the blocking threshold of 28 credits, that is approximately half of the annual credits to be passed.

The access to the Architecture BS program, which is limited in the number of enrolments at a national level, is regulated by a unified test established by the Italian Ministry of Education, University and Research (MIUR), on which the single University has no way to intervene.

For the Engineering programs, PoliTo provided an admission process since the '90s, at first based on an aptitude, not selective, paper-based test developed at a national level by CISIA, a national interuniversity consortium (Consorzio Interuniversitario Sistemi Integrati per l'Accesso 2014). In 2007, the first trial of an online test run in collaboration with CISIA involved 200 students. The previous experience as well as this trial, evidenced several limitations, in particular the need of:

- a greater flexibility, that is the possibility to offer several test dates during the year and an immediate feedback of the test results;
- an effective assessment of the aptitudes required for successfully attending the programs in a technical university thanks to a tailoring of the test contents and relative precise reporting of the specific gaps;
- a higher freedom in managing technical aspects of the informatics platform as well as the income and outcome data.

To overpass these limits the Moodle platform (Moodle s.d.) was integrated into the PoliTo web-portal to provide the design and development of an online test starting from the academic year (a.y.) 2008/09: the so-called Test in Laib (TIL). The test set-up went on until a.y. 2012/13 in which it turned from aptitude into selective, as a consequence of the introduction of the numerus clausus, as further detailed.

Thanks to the many years' experience as well as to the broad statistical database collected, TIL can guarantee transparency, robustness, and effectiveness. The test is carried out online by using a proprietary hardware and software, also allowing to better respond to the progressive, relevant increase in enrolment applications. In fact, several test dates are available starting from February each year; the applicant can repeat the test monthly and the last result achieved, expressed as a fraction of 100, is used for the ranking. A threshold of 50/100 has been set, above which the admission is guaranteed.

In the a.y. 2017/18 the total number of students enrolled in the BS and MS pro-

grams at PoliTo is about 33,000, of which about 4,500 freshmen in the BS Engineering programs. The attractiveness of international students grew progressively over the years; now around 5,000 units, about 15% of the total population, come from more than 100 foreign countries.

In fact, in contrast with the national data (Viesti 2016) but also with the situation in some other western Countries (Prieto, et al. 2009); (Morice 1990), during the last years, PoliTo has experienced a progressive increase in the number of applications for admission to Engineering BSs. This trend has been also enhanced by the relevant employment rate of its graduates, since PoliTo stands at the first place worldly, considering the indicator "graduate employment rate" in QS graduate employability ranking (QS 2017). This in spite of the high number of students graduated every year: for instance, in 2016 the BS and MS graduates were around 3,200 and 3,300, respectively.

Due to this growing demand, starting from the a.y. 2012/13 a numerus clausus of 5,000 was set, and it progressively decreased, and it was fixed at 4,500 since the a.y. 2015/16. In fact, its value is defined annually on the ground of sustainability assessments that refer to available human and infrastructural resources; it also affected by stringent national regulatory constraints, in terms of the spending review and limited turn-over of the retired teaching staff. In particular, the number of professors with permanent contracts at PoliTo is decreasing year by year, only compensated by temporary contracts (Table 1).

Table 1: Professors population at PoliTo year by year

a.y.	# professors with permanent contract	# professors with temporary contract
2011	839	0
2012	811	24
2013	788	25
2014	764	31
2015	761	43
2016	747	107
2017	729	161

To perform a reliable and robust selection, the TIL was designed and refined in such a way as:

- to guarantee the applicants to be evaluated independently from the high school diploma, mostly affected by a relevant inhomogeneity in grades (at a national level) and/or in contents (if other countries are concerned);
- to guarantee the applicant's freedom of choice and flexibility in time and place since the test is carried out in several Italian regions as well as in various non-European countries. This can improve the attractiveness of national and international students since it limits the travel and attendance costs to be incurred without any certainty of the results;
- to be reliable in the assessment of the aptitudes and of the effectiveness of the previous training, by achieving a significant correlation between test results and students' careers;
- to set up a self-assessment tool for each applicant regarding his/her previous training path and its soundness for approaching an Engineering BS, associated to the possibility of performing an on-going effort to fill any training gap for passing the admission test in due time;
- to be aimed at improving the overall quality of the freshmen and reducing the drop-out rate, through a more targeted selection at the entrance;
- to maintain a very high employability rate, thanks to the assessed quality of the graduates which can profit from a careful selection of students' input;
- to create the background for a training project aimed at the most gifted students (top 2%) which has proved to be a further stimulus to choose PoliTo as a privileged training place. This specific project will be detailed in a further contribution.

The present paper is aimed to describe this evaluation tool and to comment on its validity, through objective and statistically based results. A particular attention is addressed to the correlation between the test result and the success of the academic career, and the consequent reduction of the drop-out rate. Only the Italian students are here considered, in order to compare a homogeneous set of people who have attended a similar high school training path.

MATERIALS AND METHODS:

The data considered in this study refer to all the Italian pre-enrolled as well as enrolled students from the a.y. 2010/11 (that is from the entry into force of the so-called Gelmini reform, Italian Law 270), as detailed in Table 2.

Table 2: Number of pre-enrolled and enrolled students year by year acting as a source of the database

Type of test	a.y.	Pre-Enrolled	Enrolled
Aptitude	2010/2011	4032	3122
	2011/2012	5328	3989
Selective	2012/2013	5232	3677
	2013/2014	5780	4168
	2014/2015	6190	4432
	2015/2016	7591	4518
	2016/2017	8231	4160
Total		42384	28155

For each student, the following data are available: gender, high school diploma type, grade, year, and place. When a student enrols, other fields of the database are populated: identification number, year of enrolment, family financial status, credits and average grade earned at the end of each a.y., career end-date, last a.y. of enrolment, and BS degree mark.

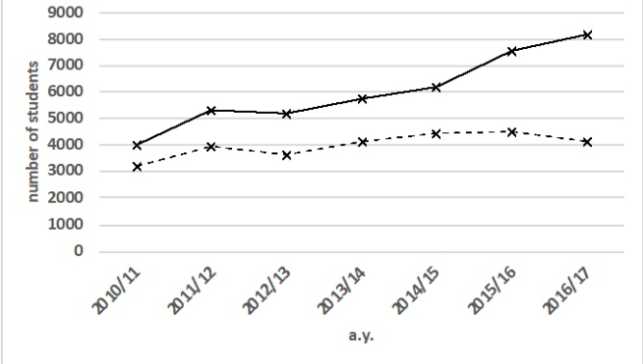
The TIL consists of 42 multiple-choice questions of varying difficulty divided into 4 sections related to the following subject areas: mathematics, physics, verbal comprehension, and logic. The total available time is 1.5 hour. The math section is made of 18 questions to be answered in 40 minutes, the physics part is composed of 12 questions to be solved in 26 minutes, while the verbal and logical comprehension parts globally consist of 12 questions in 24 minutes. Multiple answers, precisely 5 for each question, are provided, only one of which is correct. The score is calculated by assigning 1 point for each correct answer; in the event of an incorrect answer, 0.25 points are subtracted. The ungiven answers are not taken into account. The result of the test is automatically calculated and expressed as a fraction of 100, and it can be recovered at the end of the test as well as anytime on the personal web-page of each candidate. To eventually support the students in filling the specific knowledge gaps, some comments and training aids (video recording of classes, educational games, online booklets, and test training platform) are available together with the numerical results.

At the end of each exam section, the global and detailed results record are added to the PoliTo database.

RESULT AND DISCUSSION:

Increasing attractiveness and freshmen quality:

PoliTo attractiveness increased after the introduction of the numerus clausus, significantly expanding the number of candidates to be selected. The graph in Figure 1 shows that the asymptote in enrolled students imposed by the numerus clausus was reached in the last years, while the curve plotting the pre-enrolled students vs. time shows a clearly positive derivative, especially in the last two academic years.

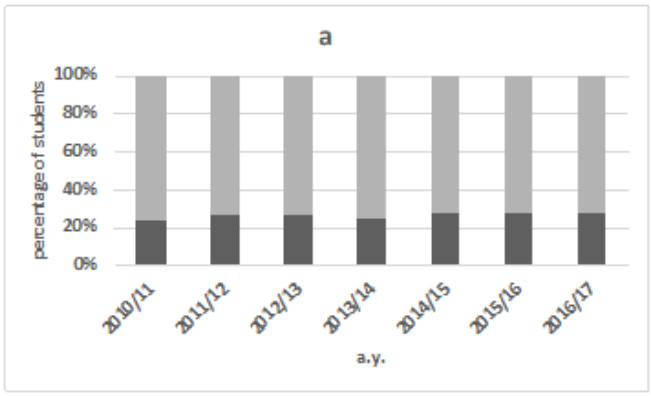


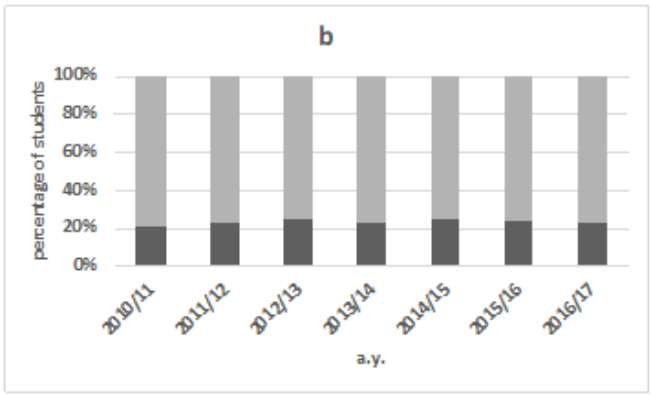
(solid line: pre-enrolled; dashed line: enrolled)

Figure 1: Trend of pre-enrolled and enrolled students year by year

In a.y. 2010/11, 80% of the applicants were enrolled after the test, whereas in a.y. 2016/17 this percentage dropped to 50%.

Even if the number of pre-enrolled students continuously increases, the male-female ratio remains almost constant (about 3:1) over time, although the total number of pre-enrolled students increases (Figure 2a). The same proportion is maintained also in the enrolled student population (Figure 2b).



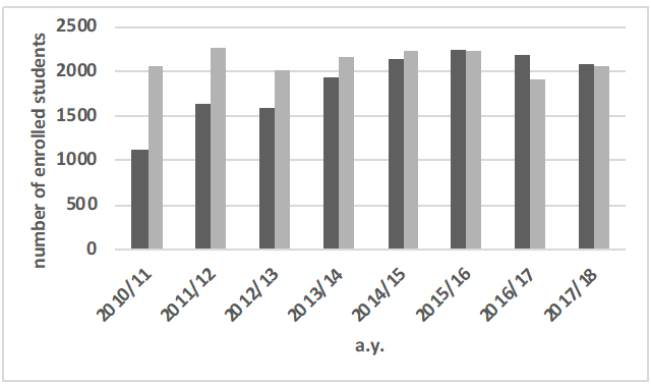


(grey: male, black: female)

Figure 2: Gender population as percentage year by year: a) pre-enrolled, b) enrolled students

These data are in agreement with the gender ratio in other technical universities in Europe (CESAER 2015) and in other countries (GE Fund 2002); (Yoder 2014).

The number of students coming from PoliTo's region, Piedmont, located in the north-west of Italy, remained almost constant over the years, whereas the freshmen coming from the other Italian regions increased (Figure 3).



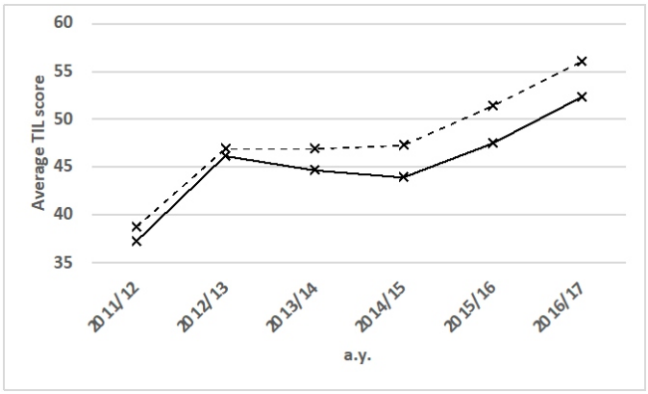
(grey: Piedmont; black: other Italian regions)

Figure 3: Number of enrolled students as a function of the region of origin

It is reasonable that the PoliTo's choice to establish a selective test has inspired confidence for the investment of households for off-site study, particularly relevant in a period of deep economic crisis such as the one object of this survey.

This is an anomalous trend in the Italian context, where there is a strong tendency to study close to the city of origin, being the universities offering engineering programs uniformly distributed throughout the country (Vergolinia e Zanini 2015).

The trend of the average TIL result during time gives evidence of a global improvement of the competence background of the students, fostered by the numerus clausus and the selective test (Figure 4).



(solid line: Piedmont; dashed line: other Italian regions)

Figure 4: Relation between region of origin and average TIL score

Starting from the a.y. 2012/13, that is when the numerus clausus was introduced, a progressive increase of the average score was recorded, corroborating that a selective test acts as a strong stimulus to improve the own competence background and consequently the success rate. Moreover, the students from outside Piedmont present a higher average quality. This is probably related both to a stronger personal motivation, which pushes them to move from the region of origin, and to the greater economic investment requested to their own families.

The introduction of a numerus clausus can also lead to a self-selection process that the potential student usually makes on the ground of the diploma grade only (the Italian high school diploma is considered passed if the grade is between 60, minimum, and 100, maximum score). However, the results of the TIL well highlight the lack of an imputable correlation between the Italian diploma grade and the competence background for a successful access and path into an Engineering BS program (Figure 5). For sake of simplicity, the TIL scores are grouped into 6 categories: A (TIL score lower than 20), B (TIL score between 20 and 34), C (TIL score between 35 and 49), D (TIL score between 50 and 59), E (TIL score between 60 and 69), and F (TIL score between 70 and 100).

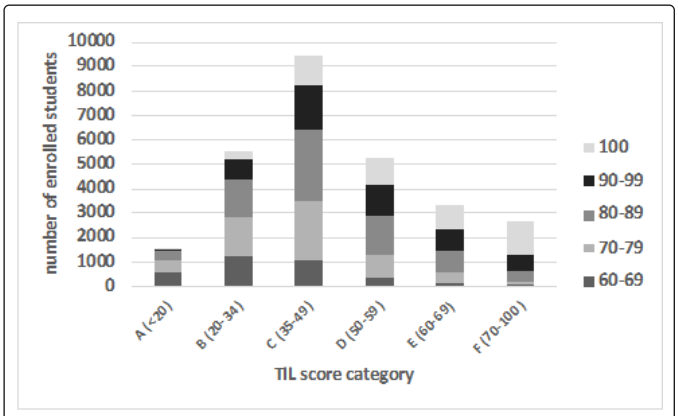


Figure 5: Relation between TIL score and high school diploma grade on the total number of enrolled students (datum given in Table 2)

The high school diploma grade seems to be better related to the most extreme test results. On the other hand, in the case of test grades between 20 and 59, the high school grade is not relevant on a sound statistical basis, as the rate of success is spread out fairly evenly.

Predictive power of the test:

The test is strongly aptitude and predictive, as one can easily notice by considering some indicators of the success of the carrier of the students enrolled from the a.y. 2010/2011 to the a.y. 2014/15 (the latest a.y. useful to collect a complete career overview in a three years' lasting course).

The first indicator, i.e. the total number of credits earned at the end of each BS year, outlines a very good correlation to the TIL result (Figure 6).

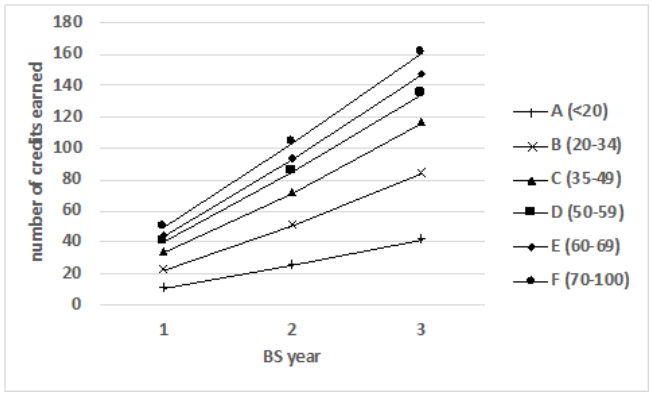


Figure 6: Correlation between the total number of credits earned and the TIL score category

In the meantime, a similar trend is observable correlating the average exam scores at the end of each BS year to the TIL result, see Figure 7.

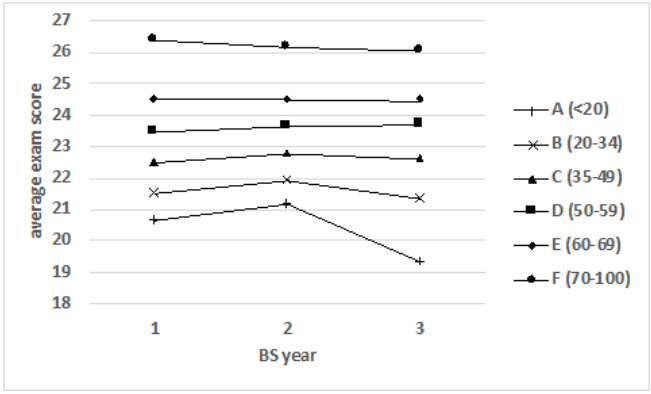


Figure 7: Correlation between average exam scores and TIL score category

A third indicator is the global carrier duration. As shown in Figure 8a, more than 60% of the students of the category F graduated in 3 years. On the contrary, almost all the students of the category A did not succeed in completing their studies within the legal duration. Considering a broader time frame that is up to 4 years from the first enrolment, the students of the category F are almost all graduated, against only 10% of students of the category A (Figure 8b).

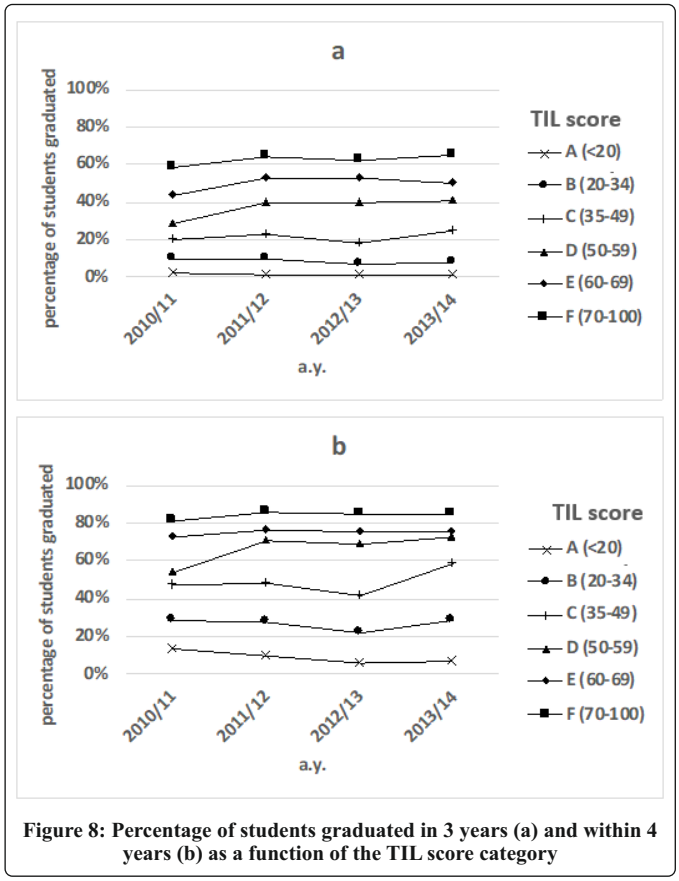
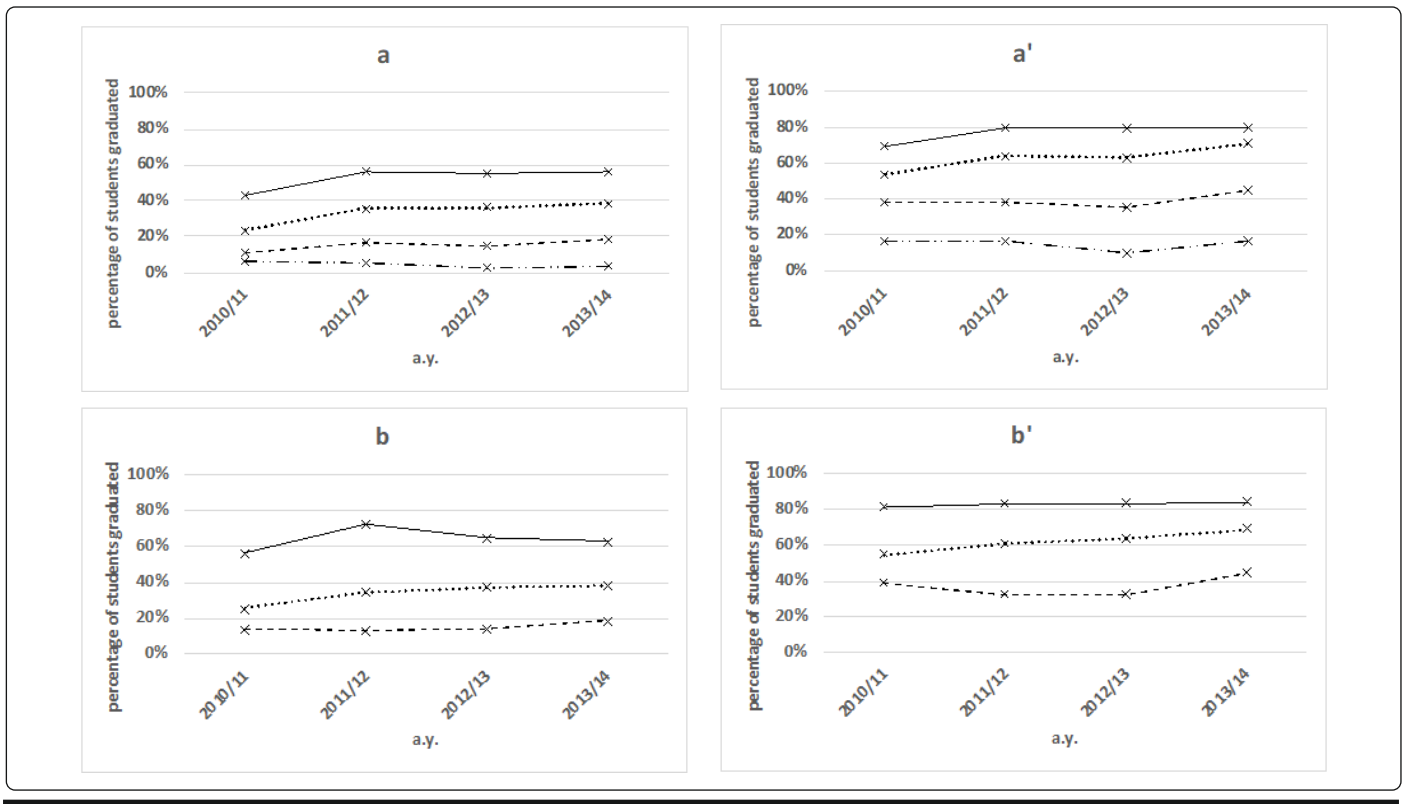


Figure 8: Percentage of students graduated in 3 years (a) and within 4 years (b) as a function of the TIL score category

A more detailed analysis can be performed by focusing on the result of each TIL section. First of all, the relation between the global career duration and the score of each section is discussed, remembering that the weight of math is 18/42, that of physics is 12/42, as well as that of logic and verbal comprehension. Again, for a sake of simplicity, the scores are grouped into categories: A (lower than 3), B (from 3 to 7.99), and C (from 8 to 12); for the mathematics one more category is added: D (from 12.01 to 18).

In , similarly to , the global carrier duration is related to the score of each TIL section.



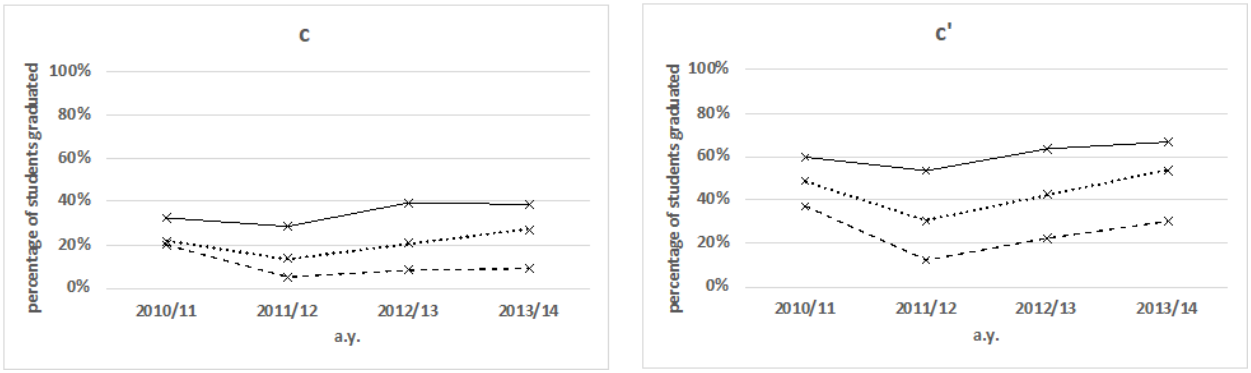


Figure 9: Percentage of students graduated in 3 years (a,b,c) and within 4 years (a',b',c') as a function of each TIL section and related categories (math (a), physics (b), and logic and verbal comprehension (c); mixed line: A; dashed line: B; dotted line: C; solid line: D)

The mathematics (a) and physics (b) parts have a preponderant weight in the predictive role of the test, while the scores of logic and verbal comprehension (c) are of lower importance. However, the relative position of the curves for the different categories remains the same for each section. As a consequence, the global structure of the test results well balanced.

Minimum test score requirement and first-year blocking threshold:
Starting from the a.y. 2015/16 a minimum test score of 20/100 must be achieved in order to be included in the final ranking. The choice of this score is justified by the strong correlation between the TIL results and the student's career (see again Figure 6, Figure 7, and Figure 8). In addition, due to the important attractiveness, and the numerus clausus, the lowest TIL score to be enrolled was over 30/100 in the last few a.ys..

On the other hand, as a confirmation of the growing quality of the incoming students, the number of them who pass the blocking threshold (28 credits) at the end of the first year is gradually increasing during the time (Figure 10).

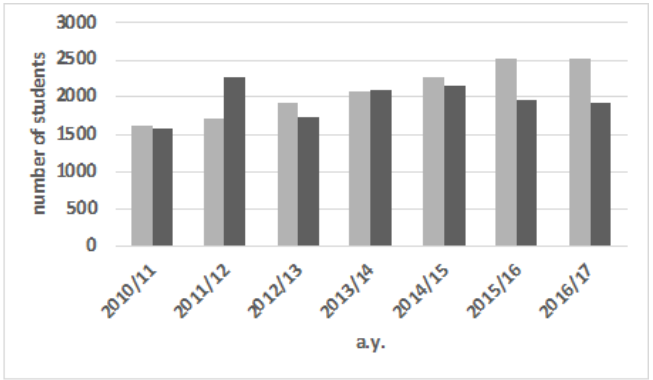


Figure 10: Number of students who passed (grey) or failed (black) the first-year blocking threshold year by year

In addition, a strong correlation can be observed between the overcoming of the blocking threshold and the TIL score (Figure 11), once again confirming the effectiveness of TIL as well as supporting the introduction of the minimum test score.

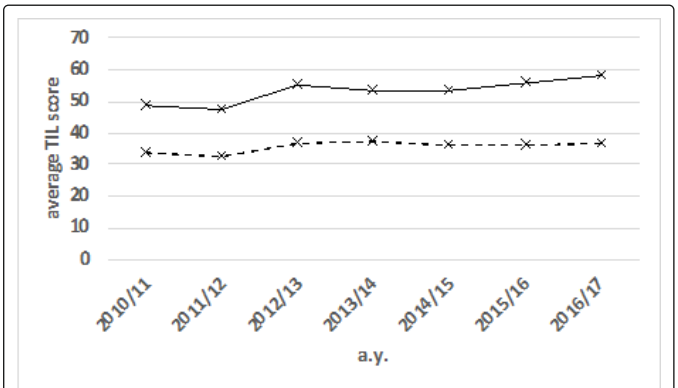


Figure 11: Average TIL score of students who passed (solid line) or failed (dashed line) the first-year blocking threshold year by year

Drop-out reduction:
The soundness of the test is also witnessed by a traceable decrease in the drop-out rate over the years. The number of active students is continuously growing, in spite of the numerus clausus, whereas the number of those who renounce within the first year of enrolment is decreasing in percentage (Figure 12).

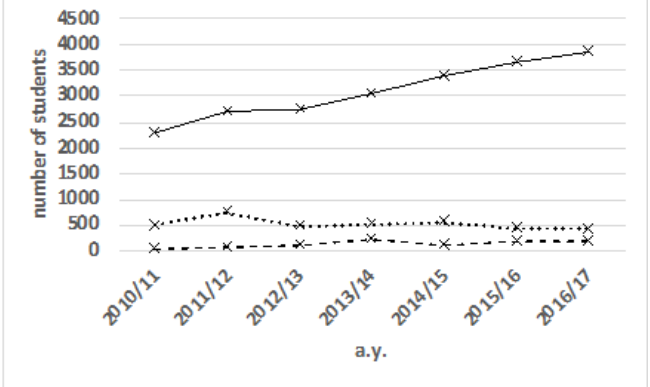
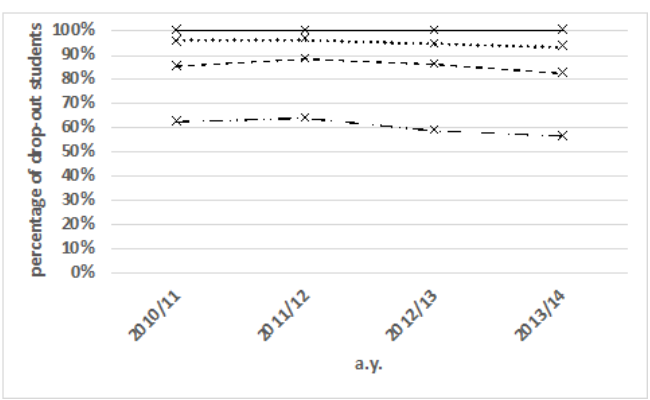


Figure 12 Trend of active (solid line), drop-out within 1st year (dotted line) and false drop-out within 1st month (dashed line) a.y. by a.y.

On the other hand, it can be observed that some students give up within the first month of the a.y., that is by October 31st (false drop-out in Figure 12). These students cannot be considered in the drop-out rate, since their leave is mostly imputable to a fail in synchronization of the national tests (for instance, for the enrolment in Medicine and Architecture studies) and consequently to a late transfer to another BS course. The most gifted candidates attend more than one the access tests and after that, they make their choice. In fact, it was observed that the number of these false drop-out increases with the increase of the TIL score.

In addition, considering also the drop-out rate within two, three, and four years, it has been observed that half of them are concentrated within the first year (Figure 13).



(mixed line: within 1st year; dashed line: within 2 years; dotted line: within 3 years; solid line: within 4 years)

Figure 13: Distribution of the drop-out population a.y. by a.y.

CONCLUSIONS:

TIL demonstrated to be:

- a reliable and robust tool for the students' selection in view of the enrolment in a technical university;
- predictable as concerns the university career goodness;
- flexible in terms of availability in time and place;
- a self-assessment exercise for the potential students to verify the quality of their own competences.

This tool, together with the introduction of a numerus clausus, the adoption of some restrictive policies in terms of minimum test score for the admission in the final ranking, and of a blocking threshold for the access to the 2nd year, has promoted some beneficial consequences. One can mention, an increase of the attractiveness and the average quality of the students, and a decrease in the drop-out rate. All these positive achievements are a benefit for PoliTo, to fulfill the sustainability requirements using a valuable selection tool based on merit. In addition, they contribute to a conscious individual choice, limiting the societal drawbacks associated with a wrong decision about the university career.

Acknowledgments:

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